THE POPULATIONS OF THE WEDGE-TAILED SHEARWATER (*PUFFINUS PACIFICUS*)[1]

By Robert Cushman Murphy

The wedge-tailed shearwater is a petrel of the tropical and sub-tropical Pacific and Indian oceans. Known breeding stations extend from the Seychelles and Mascarene Islands eastward through 193 degrees of longitude to the Revilla Gigedo Islands, off the coast of Mexico. The breeding localities are in general intertropical, but in the western Pacific, i.e., in the Bonin and New Zealand areas, they extend, respectively, slightly north of of the Tropic of Cancer and well to the south of the Tropic of Capricorn. This type of distribution accords with oceanographic conditions, as reflected in warm currents to the east of the continents and positions of the surface isotherm of 20° C. for the coolest months of the year.

The species is unknown in the Atlantic, from which it is presumably excluded by the southern tip of Africa (latitude 35° S.), which is barely extralimital in this exposed section of the belt of circumpolar westerly winds. Along the east coast of Australia the breeding range extends farther southward than elsewhere, almost, if not quite, reaching Bass Strait. In the open Pacific beyond the lee of Tasmania, however, the range withdraws again northward across the parallel of latitude 30° S. The species is not a denizen, for example, of the waters about New Zealand (fig. 1).

Puffinus pacificus has but one close relative, namely, *Puffinus bulleri*, which appears to range rather widely in the Pacific Ocean but is known as a breeding bird only from New Zealand. The
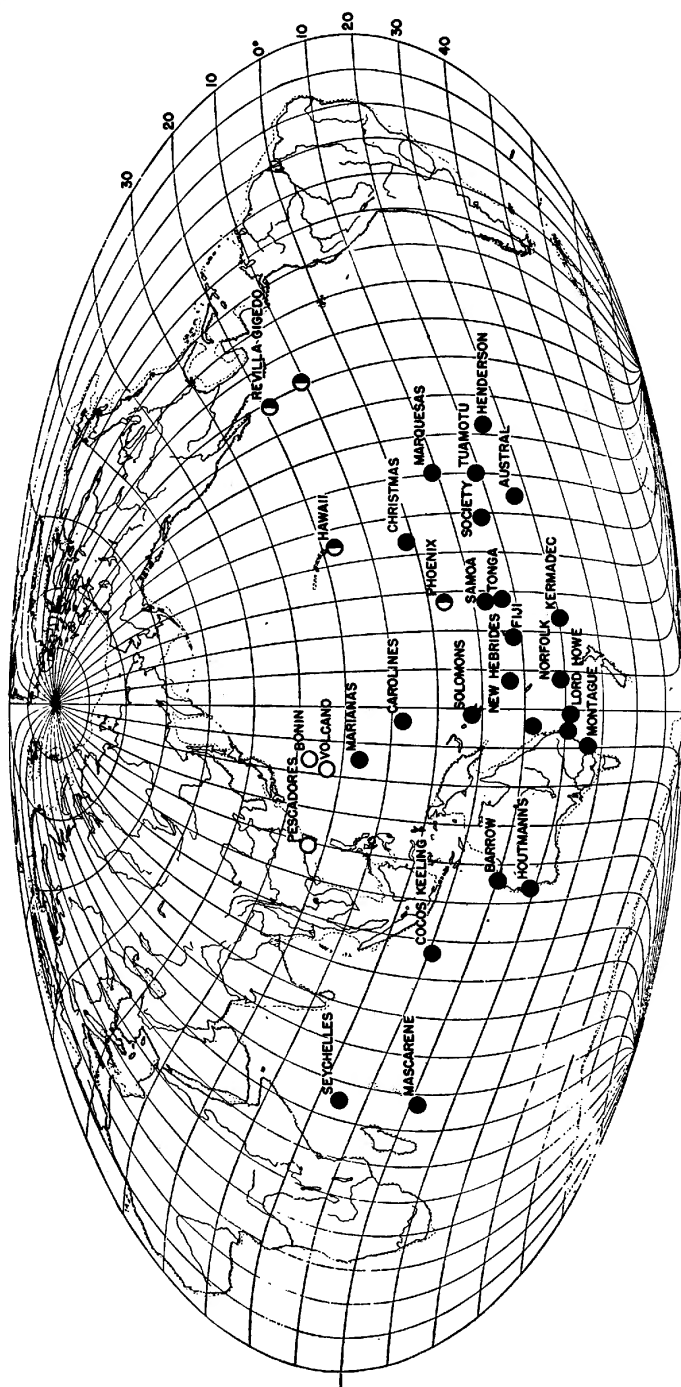
FIG. 1. Breeding range of *Puffinus pacificus*. White circles indicate populations of white-breasted birds, black circles those of all-dark birds. At stations denoted by half-black circles birds of both plumage phases are in residence, freely inter-breeding. Clipperton Island, south of Revilla Gigedo, is not known to be a nesting station, although examples of the species have been collected on the island.

two species comprise the subgenus *Thyellodroma* of Stejneger (1888), which that author distinguished from subgenus *Puffinus* by the character of a strongly graduated or cuneate tail, nearly half the length of the wing.

No fewer than 12 specific and subspecific names have been applied to alleged geographic forms of *Puffinus pacificus*. Recent systematic lists, such as that of Peters (1931), apportion trinomials and ranges in a manner reflecting the uncertainty in the literature.

The present study is a result of a request made by Dr. C. A. Gibson-Hill, of the Raffles Museum, Singapore, who submitted for identification a series of this shearwater that he had collected at the Cocos Keeling Islands, in the eastern Indian Ocean. The species is well represented in the American Museum of Natural History; besides which the writer has notes upon specimens preserved elsewhere in the United States. Recently he has added to these by examining and measuring all the shearwaters of this species in the British Museum, London, and the Muséum National d'Histoire Naturelle, Paris. The latter include the types of *P. cuneatus* and *P. chlororhynchus*. Six additional type specimens upon which subspecific names are based have likewise been used as part of a total studied series of about 400 specimens. The conclusions have populational as well as taxonomic (i.e., nomenclatural) interest.

A large share of the labor has fallen upon Miss Susan Irving, of the American Museum Department of Birds. Tested practice has made her technique of measuring specimens entirely comparable with that of the author. She also is responsible for the painstaking statistical computations upon which the tables and graphs are based, as well as for assembling and critically consulting previously published information. Dr. Dean Amadon has read the manuscript and has given the benefit of his counsel, particularly with reference to his discriminatory formula discussed below.

We have had at our disposal more than 300 adult specimens of *Puffinus pacificus* from many breeding colonies, and a small series collected on the open ocean. In several instances the latter birds were taken hundreds of miles from any possible nesting station. The difficulty of establishing the provenance of such pelagic examples, in relation to breeding grounds, is only one indication of the complexity of the systematic problem.

SPECIMENS WITH PRECISE DATA

LOCALITY	NUMBER
Seychelles Islands	25
Mascarene Islands	9
Cocos Keeling Islands	8
Coasts of Australia, east, south, and west	32
Lord Howe Island	31
Norfolk Island	22
Kandavu Island, Fiji	33
Kermadec Islands	43
Solomon Islands	1
New Hebrides Islands	26
Marianas and Caroline Islands	7
Bonin and Volcano Islands	14
Pescadores Islands (Formosa)	1
Tonga	2
Samoa	1
Canton and Phoenix Islands	15
Society Islands	16
Tuamotu and Henderson Islands	2
Austral Islands	3
Marquesas Islands	18
Christmas Island, Pacific Ocean	12
Hawaii (including the northwestern chain)	20
Revilla Gigedo Islands (including 20 of 57 specimens measured in the Carnegie Museum, Pittsburgh)	30
At sea, remote from nesting grounds	5

All adult specimens of this series have been measured and tabu-
lated with due regard for variations in the lengths of wing and tail
as correlated with molt, growth, and wear. The findings have
likewise been compared with quantitative data in earlier litera-
ture, particularly with the measurements of 47 specimens from
the Revilla Gigedo area recorded by Loomis (1918).

CHARACTERS OF SIZE AND PATTERN

So far as can be determined from museum skins and notations
on field labels, representatives of *Puffinus pacificus* vary in size, in
plumage phase, and in the colors of fleshy parts, particularly of
the bill. Unfortunately, we know least about flesh colors. As
long ago as 1831, Lesson applied the name "*chlororhynchus*" to a
form collected in west Australia, and there are indications that
birds of certain breeding localities may have yellowish bills, dis-
tinguishable from the dull and horny bill of the typical form.

Ultimate determination of such matters, which have probable
taxonomic significance, must await the kind of patient and de-
tailed life history studies that have already in several instances
supplied keys for comprehending the biology of petrels.

As regards size relationships, no sea bird could be more illumi-
nating nor at the same time more difficult to confine within a con-
ventional systematic frame of reference than this widely dis-
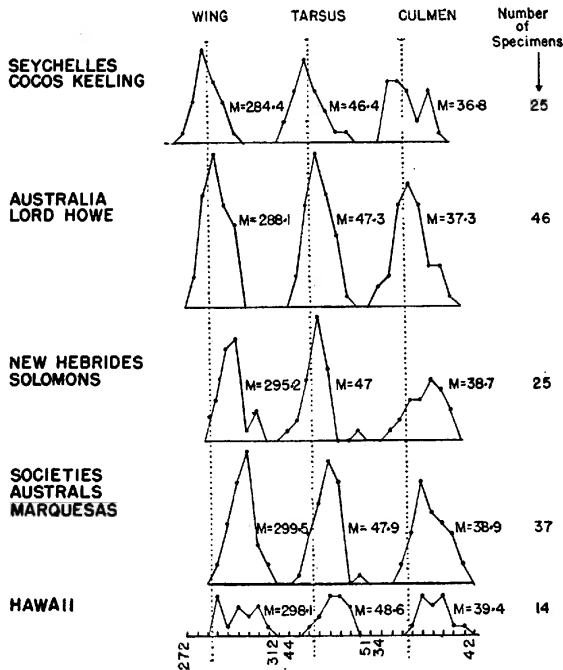

FIG. 2.   Cline of increasing size from west to east in 10 populations of *Puffinus
pacificus chlororhynchus*, as expressed by frequency distribution graphs.   Vertical
dotted lines represent means of wing, tarsus, and culmen in Indian Ocean popu-
lations.   There is a gradual increase in average dimensions of birds from the
Seychelles to the central Pacific.

tributed petrel.   Species being composed of populations rather
than of individuals, trinomial classification is primarily a matter
of convenience.   Its use is often most plausible and most con-
vincing in inverse ratio to the adequacy of the material studied.
Nature is not conventional, and in a species of exceptionally
great distribution it would doubtless require almost infinite sam-

pling before the categories of variation could be pigeon-holed in a manner to conform with our usual ideas of racial distinction.

The more subspeciation has been studied, particularly among island organisms, the more we have realized the importance of quantitative criteria of differentiation. In the present paper, the "75 per cent rule," as defined by Amadon (1949), has been taken as a standard, or at least as a point of departure. To taxonomists who might prefer a less rigorous standard for subspecies based upon size, we can only say that in *Puffinus pacificus* the somewhat irregular, and at the same time limited, nature of the variation (fig. 3) would defeat their aim. Statistically speaking, each breeding population for which we have seen a fairly adequate sampling appears to be distinct from all others. If the presence rather than the degree of distinctness were the chief subject of consideration, there might well be room for each of the numerous subspecific names that have been applied to examples of this species. It should be pointed out, however, that truly distinguishing characters have by no means been defined in the nominate descriptions, and that in nearly all instances it would be impossible to identify examples of the putative races unless the respective breeding grounds were known.

Despite this fact, the dimensional characteristics of discrete island populations have reality. Some of them can even be quantitatively expressed as clines of increasing size, extending from equatorial regions towards higher latitudes of both the Northern and the Southern Hemispheres, as though fulfilling the requirements of Bergmann's rule. A similar cline in the size of one or more characters appears to run from west to east through tropical areas of the Indian and Pacific oceans, ultimately turning northward towards Hawaii. This Miss Irving and the writer have attempted to demonstrate by a new use of frequency distribution graphs, based upon samples from five comprehensive island localities (fig. 2).

In a second diagram (fig. 3) we have plotted the dimensions of culmen, tarsus, and wing of a series of grouped samples. Each sample represents from one to four island groups and in some instances a larger number of actual breeding stations. The grouping is based upon geographic location and upon strictly comparable tables of measurements. For each sample the mean has been plotted for the number of specimens recorded at the top of the column. The first cross line on either side of the mean repre-

sents one standard deviation, and the distance from the mean to the terminal cross line, the standard deviation multiplied by 1.88. This figure was selected to illustrate Amadon's (1949) alternative formula for the "75 per cent rule," whereby if the smaller of two means plus 1.88 of its standard deviation does not exceed the larger mean minus 1.88 of its standard deviation, then 97 per cent of one population will be separable from 97 per cent of the other. This corresponds to 75 per cent of one separable from 99.9+ per cent of the other.

Figure 3 shows, incidentally, some of the difficulties of limiting subspecific categories by criteria of size. The plotted dimensions of wing, tarsus, and culmen illustrate not only the variation in populations from one island group to another, but also indicate that the Kermadec Islands, Norfolk Island, and Kandavu Island of the Fiji Archipelago are inhabited by consistently larger birds than those distributed throughout equatorial and subequatorial latitudes from the western Indian Ocean to the central Pacific. At higher parallels of the Northern Hemisphere, as at Hawaii and the Revilla Gigedo group, we find again populations of larger size, although they do not attain the dimensions of birds inhabiting the Kermadecs and the two neighboring stations named above.

The Kermadec Islands have been accepted as the type locality of the species (and therefore of the subspecies) *pacificus*. As a matter of convenience, we have nomenclaturally included within this topotypical race the birds from Norfolk and Kandavu. The diagram (fig. 3) shows at a glance, however, that both Norfolk and Kandavu populations are of intermediate size, in a definite order or progression, between the resident shearwaters of the Kermadecs and those of intertropical areas. In other words, Kermadec birds make up the only population categorically representative of the subspecies *pacificus*.

Intergradation of similar type, whether regarded as clinal or otherwise, is apparent among the various equatorial breeding populations, with the smallest members inhabiting the Indian Ocean and Australian areas as far eastward as Lord Howe Island. It is particularly noteworthy that the wedge-tailed shearwaters of Lord Howe and Norfolk Islands, which have hitherto been grouped as a single racial form (Peters, 1931, p. 55), are actually quite distinct in the means and amplitude of their dimensions, particularly of wing length.

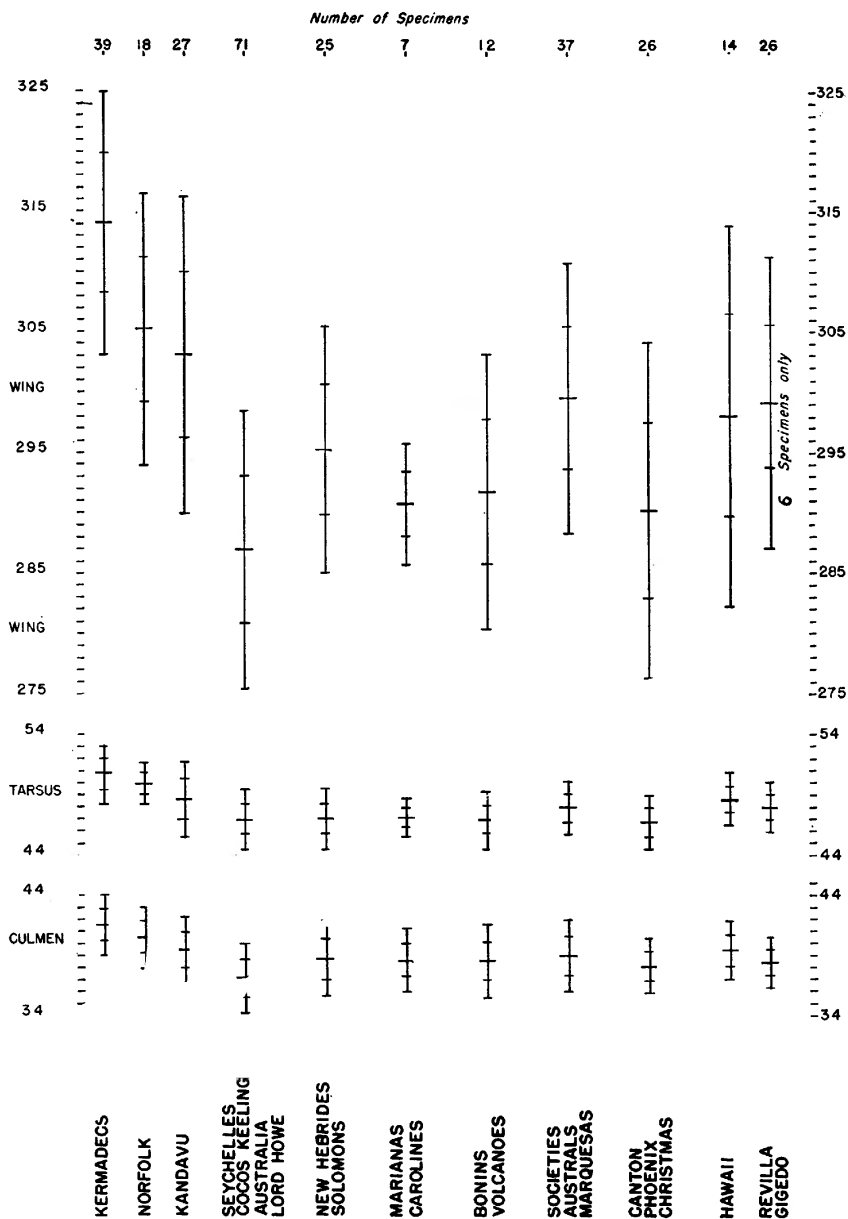Subspecific differentiation attributed to breeding populations in

FIG. 3. Variation, partly of subspecific grade, among populations of *Puffinus pacificus*. The central point of each vertical line represents the mean of wing, tarsus, or culmen for birds taken on islands or groups of islands listed at bottom of chart. The first cross lines above and below the mean line mark one standard deviation; the terminal points are placed at 1.88 times the standard deviation of the mean, a figure taken to illustrate Amadon's formula for applying the 75 per cent rule, as explained in text.

higher latitudes of the central and eastern North Pacific Ocean will be considered hereafter in relation to characters other than size.

PLUMAGE PHASES

In the Indian Ocean and in the part of the Pacific that lies south of the Equator the populations of *Puffinus pacificus* comprise almost exclusively birds of wholly dark plumage. In the Northern Hemisphere white-breasted examples become common. In certain colonies, as at the Revilla Gigedo Islands, both dark and white-breasted birds are found together in a respective ratio of about two to one. In the Hawaiian area the proportion of white-breasted examples is higher, and at the Bonin and Volcano Islands close to Japan, and the Pescadores group in the Taiwan or Formosa Strait, it appears to approach 100 per cent. The Pescadores, which lie almost on the Tropic of Cancer, are the westernmost breeding station in the North Pacific.

Here it should be emphasized, however, that the segregation of uniform and bicolored birds, whether complete or partial, offers no clue to subspecific discrimination. It would almost accord with the truth to divide the species as a whole into dark birds in the Southern Hemisphere and white-breasted or mixed populations in the Northern Hemisphere, except for the fact that a single white-breasted example was obtained by Mr. Beck during the Whitney South Sea Expedition at Canton Island of the Phoenix group, which lies less than 3 degrees south of the Equator (latitude 2° 44′ S.). The statistical frequency of this plumage at Canton is probably vastly less than the proportions (1:17) represented in the available series of specimens, because Beck and his associates always made a particular effort to obtain any unusual plumage types encountered in their field work. From Canton Island northward, spreading fanwise towards the extra-tropical Pacific, the proportion of white-breasted birds increases in clinal fashion, reaching its highest incidence at northerly, and particularly at westernmost, Pacific breeding stations.

In addition to unicolored and bicolored plumage patterns, a third phase, with a "masked white" ventral surface, also turns up in various populations of *Puffinus pacificus*. It seems to be present only in areas inhabited by a proportion of white-breasted birds. Godman (1908, p. 79) and Loomis (1918, p. 144) refer briefly to this type of plumage. Among our American Museum
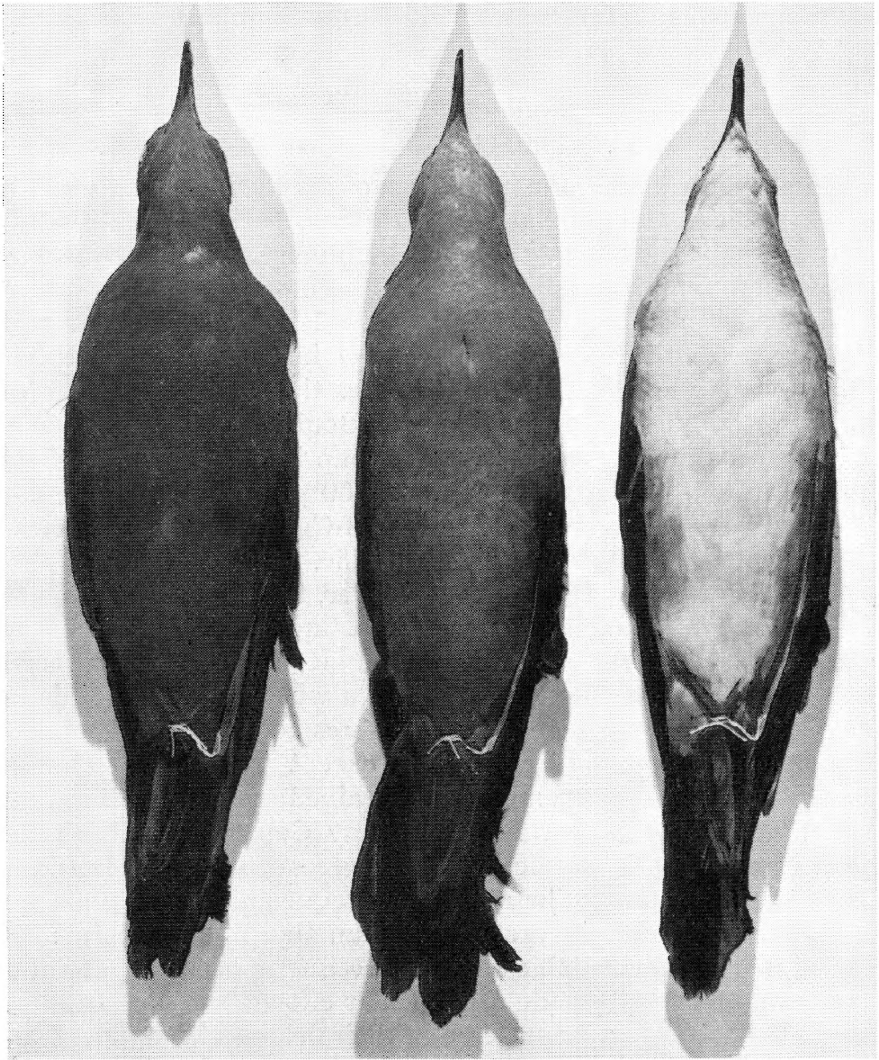
FIG. 4. Three plumage phases of *Puffinus pacificus chlororhynchus*, all collected at Canton Island on March 14, 1924. Black phase, A.M.N.H. No. 205895, male; masked white or gray-breasted phase, A.M.N.H. No. 205578, male; white-breasted phase, A.M.N.H. No. 205896, female.

specimens, one from Canton Island, one from Hawaii, and three from the Revilla Gigedo group represent such a gray-breasted phase, in which the concealed part of the ventral plumage is much more extensively whitish than in brown birds. There are

thus three presumably genetic plumage patterns, viz., all-dark, white-breasted, and an intermediate pale-breasted (fig. 4).

As taxonomic characters, these plumage phases are meaningless. It would be impossible to distinguish a Lord Howe Island bird, where the whole population is dark, from a brown Hawaiian bird, where half the population may be white-breasted. In like manner, a specimen from the completely white-breasted Bonin Island population is a counterpart of the only white-breasted bird known from Canton Island.

The several phases are in all probability examples of balanced polymorphism, which may fluctuate widely. They are likely to vary temporally as well as spatially. There is already good evidence that a single population of a petrel (*Pterodroma hasitata*) at Guadeloupe, French West Indies, was made up of mixed (black-and-white) birds at one period, whereas less than half a century later the resident birds were all dark (Murphy, 1936, p. 696). Future studies may show similar changes in populations of *Puffinus pacificus* of the Pacific and Indian oceans, as a result of the never-stabilized flow of genes. It would be surprising, indeed, if more intensive search at Southern-Hemisphere localities failed to turn up even now an occasional white-breasted example among the colonies of dark birds.

SEXUAL DIMORPHISM

Some species of petrels, including members of the genus *Puffinus*, are characterized by notable difference in the size of the sexes. This is not true of *Puffinus pacificus*. In figure 5, two sets of frequency distribution graphs, based, respectively, upon 100 specimens of *Puffinus kuhli borealis* and an equal number of *Puffinus pacificus chlororhynchus*, illustrate the relationships.

Since sexual dimorphism is usually correlated with specialized courtship and mating behavior, further study in the field will be needed to interpret the significance of the discrepancies. In table 1, the measurements of both sexes have been combined.

THE LIFE CYCLE

Information derived from exhaustively studied petrels, such as *Puffinus puffinus*, indicates that the larger shearwaters spend approximately two-thirds of the year in close association with the breeding stations and the other third at sea. In higher latitudes

of each hemisphere the birds are likely to be completely absent for four months, more or less. In an intertropical belt, where migration among many species is less extensive, it is a not uncommon phenomenon to find some members of a population
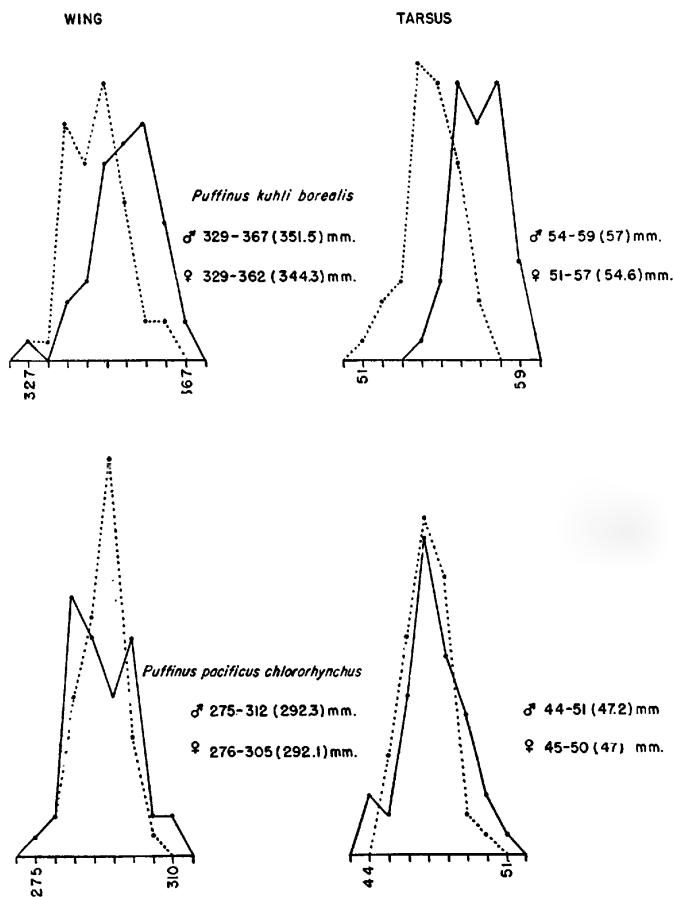
WING   TARSUS

Puffinus kuhli borealis

♂ 329–367 (351.5) mm.   ♂ 54–59 (57) mm.

♀ 329–362 (344.3) mm.   ♀ 51–57 (54.6) mm.

327   367   51   59

Puffinus pacificus chlororhynchus

♂ 275–312 (292.3) mm.   ♂ 44–51 (47.2) mm

♀ 276–305 (292.1) mm.   ♀ 45–50 (47) mm.

275   310   44   51

FIG. 5. Sexual size discrepancy and its absence. Upper graphs, from Murphy (1924, pp. 248–249), show lengths of wing and tarsus among 50 males and 50 females of a species from a single nesting colony in the Azores. Lower graphs depict similar data derived from 50 males and 50 females of *Puffinus pacificus chlororhynchus* of several populations.

making use of their nesting shelters even during the non-breeding season.

Data on the life cycle of *Puffinus pacificus* have been derived from such specimens as eggs, downy young, and fledglings, as well

as from notes on labels or in field journals describing the condition of the gonads in adults and the capture of single birds or mated pairs in burrows. In the case of a very few localities, information rests upon notes recorded by naturalists during lengthy stays at breeding stations. Knowledge derived from sources of these two types has been pieced out slightly by induction and interpolation. At present we can construct a reasonably satisfactory picture only for nesting stations at a maximum distance from the Equator, such as the Revilla Gigedo and Hawaiian Islands in the Northern Hemisphere, and Norfolk Island and the Kermadecs in the Southern Hemisphere. In these paired groups of breeding areas, the period of reproduction naturally shows a seasonal reversal.

In a general way, the succession in all colonies close to the Equator seems to agree more nearly with the regime of the Southern Hemisphere than with that of the Northern Hemisphere. This might be expected because of secular climatic differences between the Northern, or "terrestrial," Hemisphere and the "water" hemisphere comprising the southern half of the globe. In other words, the influence of the vast southern, circumpolar ocean extends over somewhat into the smaller oceanic basins north of the Equator.

The intertropical concordance is still confusing, however, because of insufficient data. The cycle among certain equatorial and subequatorial populations of this species may be less strictly seasonal than among birds nesting in higher latitudes. On the other hand, it may prove in some tropical localities to be pronouncedly seasonal but determined by relatively local wet and dry conditions rather than by the large-scale annual cycle.

Figure 6 represents an attempt to correlate and compare, month by month, the life cycle of *Puffinus pacificus* at Hawaii (latitude 20° + N.) and the Revilla Gigedo Islands (latitude 19° N.) with that at the Kermadecs (latitude 30° S.) and Norfolk Island (latitude 29° S.). Both the calendar periods and the length of the successive stages in the life history must be accepted as provisional and approximate. Among nearly all species of sea birds inhabiting the warmer oceanic areas the dates of return to nesting grounds, pairing, egg-laying, etc., seem to be less rigidly fixed than in species that nest in high temperate or subpolar latitudes. We have found, for example, the record of an unhatched egg of *Puffinus pacificus* at Norfolk Island as late as

HAWAII AND REVILLA GIGEDO		KERMADEC AND NORFOLK
Jan.	**NO BIRDS ON BREEDING GROUND**	July
Feb.		Aug.
Mar.		Sept.
Apr.	**ADULTS ARRIVE, COURT, MATE, AND BURROW (± 60 DAYS)**	Oct.
May		Nov.
June	**EGG LAID**	Dec.
July	**INCUBATION (± 50 DAYS)**	Jan.
Aug.	**YOUNG HATCH**	Feb.
Sept.	**YOUNG FLEDGE, ADULTS DEPART (± 70 DAYS)**	Mar.
Oct.		Apr.
Nov.	**YOUNG DEPART**	May
Dec.	**NO BIRDS ON BREEDING GROUND**	June

FIG. 6. Scheme to illustrate approximate life cycle of two relatively high-latitude populations of *Puffinus pacificus* on either side of the Equator.

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March 17. Nevertheless, figure 6 seems, on present evidence, to represent the normal annual cycle, the biological activities in the middle column being correctly associated with the periods in which these activities prevail in the bulk of the petrel populations.

To return to consideration of tropical colonies, Gibson-Hill reports that at Cocos-Keeling these shearwaters have taken possession of the breeding grounds by September, that eggs are laid in October and November, and that the chicks are well grown in January. This would represent an advance of only a month or two over the cycle at the Kermadecs. Scattered and fragmentary evidence regarding the presence of eggs and downy young at the Seychelles, islands off New South Wales, Lord Howe, New Hebrides, Phoenix Islands, Christmas Island (Pacific Ocean), Societies, Tuamotus, Marquesas, and the Australs likewise suggests a departure of only about the same length of time, in one direction or the other, from the seasonal regime indicated for the Kermadecs. Our knowledge concerning most of these stations can be little more than conjectural, however, until further field studies have been made. It is interesting that adult specimens have been taken at Christmas Island during August, which falls in the vacation season of the year under the Southern Hemisphere system. It is not yet known whether this reflects an earlier onset of nesting at a station only 2 degrees from the Equator or indicates the use of the burrow as a shelter during the non-breeding season.

TAXONOMY
Puffinus pacificus pacificus

Procellaria pacifica GMELIN, 1789, Systema naturae, vol. 1, pt. 2, p. 560 (Pacific Ocean; type locality restricted to Kermadec Islands by Mathews, 1912, Birds of Australia, vol. 2, p. 80).

Puffinus chlororhynchus iredali MATHEWS, 1910, Bull. Brit. Ornith. Club, vol. 27, p. 40 (Sunday Island, Kermadecs).

Puffinus pacificus whitneyi LOWE, 1925, Bull. Brit. Ornith. Club, vol. 45, p. 106 (Kandavu Island, Fiji).

The example upon which Gmelin based the original description probably did not come from the Kermadecs. But no type specimen exists, and a series of uncertainties may best be closed by accepting the designation of Mathews.

This typical race, so far as yet known, is composed only of birds in the dark phase. Its members, particularly those from the topotypical locality (the Kermadec Islands), are distinguish-

TABLE 1

COMBINED MEASUREMENTS OF MALES AND FEMALES OF *Puffinus pacificus*

Puffinus pacificus ♂ and ♀	Culmen	Tarsus	Wing
Kermadec Is. 39 specimens	39.5–44.2 (41.5 ± .21) S.D. = 1.31 V = 3.15	47.1–53.4 (50.7 ± .20) S.D. = 1.25 V = 2.47	300–327 (314.0 ± .93) S.D. = 5.81 V = 1.85
Norfolk I. 18	38.2–43.2 (40.5 ± .32) S.D. = 1.34	47.9–51.4 (49.9 ± .21) S.D. = .90	294–317 (305.2 ± 1.4) S.D. = 6.03
Kandavu, Fiji 28	37.2–42.8 (39.4 ± .28) S.D. = 1.48	46.0–51.7 (48.6 ± .31) S.D. = 1.65	293–326 (303.1 ± 1.31) S.D. = 6.94
Seychelles Is., Cocos Keeling Is., Australia, Lord Howe I. 72	34.2–41.1 (37.1 ± .18) S.D. = 1.56 V = 4.19	44.2–49.9 (47.0 ± .15) S.D. = 1.32 V = 2.80	272–300 (286.9 ± .72) S.D. = 6.12 V = 2.13
New Hebrides, Solomons 27	35.1–41.5 (38.7 ± .33) S.D. = 1.65	43.9–51.2 (47.0 ± .25) S.D. = 1.32	287–309 (295.2 ± 1.04) S.D. = 5.41
Marianas, Carolines 7	36.2–40.5 (38.6 ± .56) S.D. = 1.45	46.0–48.5 (47.1 ± .32) S.D. = .84	287–294 (290.7 ± 1.02) S.D. = 2.66
Bonins, Volcanoes 13	35.7–41.1 (38.5 ± .44) S.D. = 1.59	44.2–48.6 (46.9 ± .34) S.D. = 1.20	280–299 (291.7 ± 1.68) S.D. = 6.04
Society Is., Australs, Marquesas 37	35.7–42.0 (38.9 ± .25) S.D. = 1.55 V = 4.0	45.2–50.8 (47.9 ± .19) S.D. = 1.17 V = 2.44	289–314 (299.5 ± .97) S.D. = 5.94 V = 1.98
Canton I., Phoenix Is., Christmas I. 27	36.0–40.6 (38.1 ± .24) S.D. = 1.23	43.8–49.2 (46.7 ± .23) S.D. = 1.18	275–306 (290.2 ± 1.41) S.D. = 7.34
Hawaii 14	37.5–42.0 (39.4 ± .34) S.D. = 1.27	46.3–50.4 (48.6 ± .31) S.D. = 1.14	285–312 (298.1 ± 2.27) S.D. = 8.40
Revilla Gigedo 26	35.8–40.5 (38.4 ± .22) S.D. = 1.14	45.8–50.3 (48.0 ± .22) S.D. = 1.11	293–312 (299.2 ± 2.57) S.D. = 6.41 (6 specimens only)

able from other examples of the species by slightly larger average size and a heavier bill.

The slightness or weakness of taxonomic distinction for even this "large" race is, however, indicated in figure 3, which shows that only in length of wing does the subspecies fulfill the requirements of the 75 per cent rule. Wing dimension can be regarded as the most stable of the three sets of measurements calculated, since the coefficient of variation proved smaller than those of culmen and tarsus (table 1).

Norfolk Island specimens are closer to the subspecies *pacificus* than to the only other subspecies here recognized. Kandavu specimens are similar, although intermediate in slightly greater degree.

We have no knowledge of Fijian representatives from islands other than outlying and relatively isolated Kandavu, on the southern border of the archipelago.

Puffinus pacificus chlororhynchus

Puffinus chlororhynchus LESSON, 1831, Traité d'ornithologie, livr. 8, p. 613 (type from Shark's Bay, Western Australia).

Puffinus sphenurus GOULD, 1844, Ann. Mag. Nat. Hist., vol. 13, p. 365 (Houtman's Abrolhos, Western Australia).

Nectris gama BONAPARTE, 1856, Conspectus avium, vol. 2, p. 202 (Indian and Pacific oceans).

Puffinus cuneatus SALVIN, 1888, Ibis, p. 353 ("Krusenstern Island" = one of the chain of Leeward Islands of Hawaii).

Puffinus knudseni STEJNEGER, 1888, Proc. U. S. Natl. Mus., p. 93 (Kauai Island, Hawaii).

Puffinus pacificus hamiltoni MATHEWS, 1912, Birds of Australia, vol. 2, p. 82 (Seychelles Islands).

Puffinus pacificus laysani MATHEWS, 1912, *op. cit.*, vol. 2, p. 83 (Laysan Island).

Puffinus pacificus alleni MATHEWS, 1912, *op. cit.*, vol. 2, p. 83 (San Benedicto Island, Revilla Gigedos).

Puffinus pacificus royanus MATHEWS, 1912, *op. cit.*, vol. 2, p. 85 (Bondi Beach, New South Wales).

In the description of *Puffinus cuneatus*, a widely accepted name, Salvin wrote: "The Krusenstern Islands here referred to are apparently the small cluster of islands so named by Kotzebue, which form part of the Marshal Group. . ." This has been interpreted to mean the island of the Marshalls now known as Ailuk (Godman, p. 76; Fisher, 1946, p. 587).

The writer's investigations at the British Museum have es-

tablished that Salvin's type was actually attributed to "Krusenstern Reef," south of Lisiansky Island of the Hawaiian chain. It was collected and labeled by H. J. Snow in the spring of 1883. Other sea birds in the same collection, including the petrel *Pterodroma leucoptera hypoleuca*, bear field labels with the same data and handwriting. Seebohm (1890, p. 107), who also received specimens from the same source, wrote: "I have a skin which was procured by Mr. Snow in the spring of 1883 on Krusenstern Island, about forty degrees to the east of the Bonin Islands." This position, it should be noted, was the one assigned to "Krusenstern Reef" (latitude 22° 15′ N., longitude 175° 37′ W.) until it was eliminated altogether from the hydrographic charts.

The mythical islet, rock, or reef, as it has been variously designated, was reported and named by Lisiansky on October 23, 1805. It was carried on most maritime charts until a few years ago, although latterly with the annotation "position doubtful" or "existence doubtful." As a result of a search conducted in 1923 by the U.S.S. "Milwaukee," the non-existence of this hazard to navigation was officially advertised in a "Notice to Mariners" issued by the Hydrographic Office at Washington.

Why, then, should sea birds have been labeled by the collector with the name of an apocryphal locality? The answer has been made clear to the writer by Dr. James C. Greenway, Jr., of the Museum of Comparative Zoölogy, who had independently arrived at the conclusion that the "Krusenstern" of Snow was in the Hawaiian chain.

Henry James Snow was a hunter of seals and sea otters, who operated out of Yokohama between 1873 and 1888. He published two books in the nature of a diary of this period. He never visited the Marshall Islands but is known to have cruised among the Leeward Islands of Hawaii.

Snow carried out his raids in areas that were closed, either *de facto* or *de jure*, to sealers, as indicated by the title of his last book, "In forbidden seas," London, 1910. On at least one occasion he and his craft were seized for poaching. His interest in the Hawaiian chain may have been concerned chiefly with the tropical seal (*Monachus*), or with feathers for the millinery trade. "Krusenstern Island" would be a convenient locality name for a man who had no wish to leave a record of the fact that he had landed on the neighboring islands of Laysan, Lisiansky, etc.

From such determinations, we may conclude that *Puffinus*

TABLE 2

Dimensions of the Two Races of *Puffinus pacificus*

	Wing	Tail	Culmen	Tarsus	Middle Toe and Claw
P. p. pacificus					
38 males from 3 localities	295–327 (309.2)	130.6–145.3 (136.4)	37.7–44.0 (41.2)	46.0–53.1 (50.1)	54.3–63.8 (60.6)
47 females from 3 localities	293–326 (308.0)	123.2–147.4 (137.5)	37.2–44.2 (40.2)	46.5–53.4 (49.7)	52.8–65.7 (60.0)
P. p. chlororhynchus					
106 males from 16 localities	275–314 (292.1)	119.0–145.2 (132.5)	34.7–42.0 (38.4)	43.8–51.2 (47.3)	52.4–61.1 (56.8)
102 females from 15 localities	272–308 (292.2)	120.5–142.3 (132.9)	34.2–42.0 (37.9)	44.2–50.4 (47.2)	51.6–61.2 (56.6)

cuneatus is synonymous with *sphenurus* and *knudseni* and consequently with *chlororhynchus*.

Pending criteria not yet pointed out, all examples of *Puffinus pacificus* other than the birds from the Kermadecs, Norfolk Island, and Kandavu should be referred to a single subspecies, *chlororhynchus*. The populations of this form vary as shown in the preceding text and figures, but there is among them no adequate quantitative basis of taxonomic discrimination.

TABLE 3

MEASUREMENTS OF EGGS OF THE TWO RACES OF *Puffinus pacificus*

	Length	Breadth
P. p. pacificus		
2 eggs, from Sunday Island, Kermadecs (Oliver, 1930, p. 119)	66.5–69.5 (68.0)	44.0–44.5 (44.3)
P. p. chlororhynchus		
6 eggs, from Tanna, Lord Howe, and Christmas Islands (Pacific Ocean)	60.5–64.9 (62.5)	40.1–42.3 (41.1)

Dimensions according to sex within both subspecies are set forth in table 2. It is noteworthy that measurements of a small number of eggs, summarized in table 3, likewise confirm the division of the species into two races.

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